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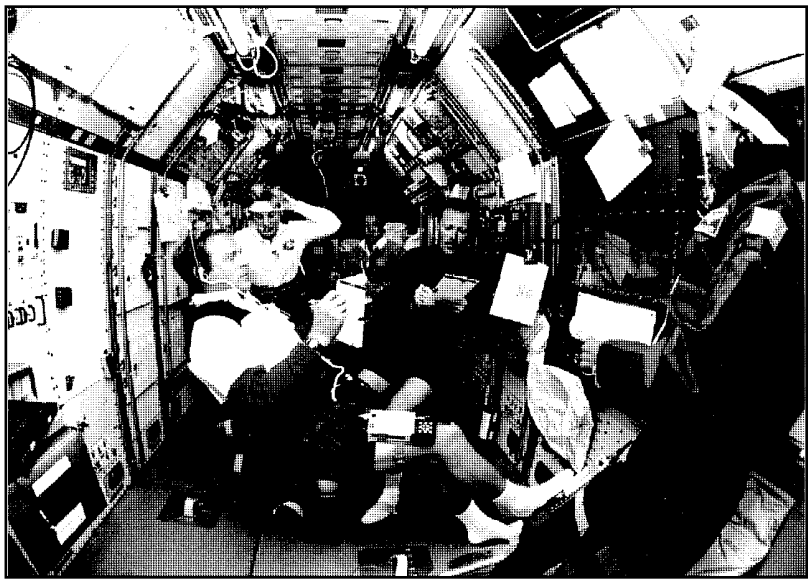
Mission Highlights STS-47

Space Shuttle *Endeavour*

September 12-20, 1992

Commander:
Robert L. Gibson (Capt., USN)
Pilot:
Curtis L. Brown (Maj., USAF)
Payload Commander:
Mark C. Lee (Lt. Col. USAF)
Mission Specialists:
Jerome Apt (Ph.D.)
N. Jan Davis (Ph.D.)
Mae C. Jemison (M.D.)
Payload Specialist:
Mamoru Mohri (Ph.D.)



Six of the seven crewmembers of the Spacelab-J mission conduct a "handover" during a shift change in the Spacelab. Spacelab-J crewmembers conducted around-the-clock science operations.

Major Mission Accomplishments

- Conducted the first joint United States and Japan Space Shuttle mission. Carried the "First Materials Processing Test" (Spacelab-J).
- Completed the third microgravity laboratory Space Shuttle flight of 1992 and the first Japanese precursor research to Space Station *Freedom*.
- Completed the second flight of NASA's newest Space Shuttle, *Endeavour*.
- Obtained data on 43 microgravity experiments in the areas of materials and life sciences.
- Contacted several schools using the Shuttle Amateur Radio Experiment (SAREX).
- Conducted a live half-hour Japanese educational lesson shown during the evening in Japan.
- Performed a successful In-Flight Maintenance (IFM) procedure to repair a cooling-water leak allowing four furnaces to provide operations to 8 experiments.
- Completed the first ever shedding, fertilization, and development of (frog) eggs in space.

The Space Shuttle *Endeavour*, on its second flight, lifted off with Japan's "First Materials Processing Test," also known as Spacelab-J (SL-J). STS-47 represented a joint venture between the National Space Development Agency of Japan (NASDA) and the United States' National Aeronautics and Space Administration (NASA). Spacelab-J was a collection of 34 materials and life science experiments sponsored by NASDA. NASA sponsored seven experiments and NASDA and NASA jointly sponsored two additional experiments for a total of 43 experiments conducted around-the-clock by crewmembers during *Endeavour's* eight-day flight. To produce the best possible microgravity environment for the experiments, *Endeavour* was placed in a "gravity gradient" attitude with its tail pointed towards Earth. Microgravity is a term that refers to an acceleration that is small when compared to the gravitational attraction at Earth's surface. Through the action of free fall (e.g., Space Shuttle orbiting Earth), the local effects of gravity are reduced, thus creating a microgravity environment. The "gravity gradient" attitude allows the Shuttle's attitude to be maintained by gravitational and atmospheric drag forces and reduces the need for orbiter thruster firings which could disturb sensitive experiments.

Spacelab-J crewmembers, including the first Japanese Payload Specialist and the first African-American female, conducted 22 materials sciences experiments exploring the areas of electronic materials, fluid dynamics and transport phenomena, glasses and ceramics, metals and alloys, and biotechnology. The experiments attempted to produce new products, evaluate new or improved production methods, and examine the suitability of microgravity for certain manufacturing processes. There were also 20 life sciences investigations in the areas of biotechnology, cell biology, developmental biology, human physiology, and radiation and environmental health. Another investigation monitored the accelerations produced during the mission to provide further information to researchers about Spacelab's environment. Some of the Spacelab-J experiments are described below.

STS-47 crewmembers (L to R, front): N. Jan Davis, Mark C. Lee, Mamoru Mohri, (L to R, rear) Robert L. Gibson, Curtis L. Brown, Mae C. Jemison, (Center) Jerome Apt.

Materials Science

Electronic Materials

Advancements in semiconductor technology can lead to smaller, more efficient electronics for products such as computers and audio/visual equipment. In the electronic materials experiments, five kinds of semiconductor crystals were grown using three specialized furnaces—the Gradient Heating Furnace, the Image Furnace, and the Continuous Heating Furnace—where crystal compounds were melted, combined, and cooled into solid form. On the second day of the flight, the crew performed an in-flight maintenance procedure to stop a leak in the water-cooling loop for the furnaces, allowing them to operate. The resulting crystals were returned to Earth for study, which may lead to a better understanding of manufacturing similar crystals on Earth and thus more efficient electronic components.

Fluid Dynamics and Transport Phenomena

Three fluid dynamics and transport phenomena experiments studied the underlying physics at work when fluids are subject to different conditions in microgravity. The Liquid Drop Experiment Facility used acoustic (sound) waves to suspend and manipulate liquid drops. Knowledge gained through this experiment may promote the development of containerless processing methods for use on Earth. The Bubble Behavior Unit and the Marangoni Convection Experiment Unit studied Marangoni convection—fluid movement caused by surface tension variations between regions of different temperatures. On Earth, liquids are affected by buoyancy-driven convection: when a fluid is heated, less dense fluids rise and more dense fluids fall. In microgravity, bubbles generated disperse differently. Marangoni convection is one of many phenomena that must be better understood for materials-processing techniques to become more effective.

Glass and Ceramics

The Acoustic Levitation Furnace used acoustic waves to suspend, combine, manipulate, and melt ingredients for a non-silicon-based glass used in infrared-detecting devices, such as night-vision goggles and telescope lens. This containerless process could lead to a more transparent glass. The Image Furnace was used to collect data on the physical process of melting glass and producing a rare mineral compound (Samarskite) to better understand its properties.

Metals and Alloys
A series of metals and alloys experiments looked into the ways that ingredients may be combined to form new, improved materials. The Large Isothermal Furnace was used to heat samples with uniform temperature in a vacuum chamber. In space, the ingredients can be more completely mixed as they float in the microgravity environment. Understanding of such processing may lead to lighter, more stress-resistant metals, as well as more uniform semiconductors and superconductors.

Biotechnology
Biotechnology is a research field that seeks to adapt biological and engineering data to benefit humankind. Protein crystal growth experiments on Spacelab-J were grown by both vapor diffusion and liquid/liquid diffusion. Larger protein crystals can be grown in space than on Earth. The functions of most biological molecules are determined by their three dimensional structure. Larger crystal structures free of deformations caused by gravitational effects allow scientists to identify the structure more easily. This knowledge may lead to the development of new and improved medicines and synthetic products.

Life Sciences

Developmental Biology
Two experiments investigated the effects of microgravity on animal development. Female frogs were carried onboard Spacelab-J; their eggs were fertilized during flight and developed into tadpoles in microgravity. Another experiment studied the effect of microgravity on calcium metabolism and bone formation in chick embryos.

Cell Biology
Three cell culturing experiments grew plant and animal cells while in orbit. This allowed for the phyiological changes that occur in plants and animals to be examined at the cellular level. In particular, these experiments looked at the changes in enzyme production in space.

Physiology
These experiments will reveal more about how organisms function in microgravity. One experiment, Comparative Measurement of Visual Stability in Earth and Cosmic Space, examined head and eye movements while the crewmember visually tracked a flickering light target. Crewmembers also participated in experiments on physical adaptation to space, including urine collection studies to gauge the intake and output of fluids. The Magnetic Resonance Imaging After Exposure to Microgravity experiment used magnetic field and radio waves to produce an image of the inside body to examine crewmember calf and thigh muscles and to look for changes in spinal bone marrow and vertebrae.

Biological Material Separation
Two experiments used free-flow electrophoresis to separate biological material with different charges into individual components, using an electric field. Certain proteins and cellular components can be difficult to separate on Earth because gravity causes convection currents and sedimentation which can remix components. The highly-purified components produced in microgravity may contribute to the development of pharmaceuticals and biomedical research.

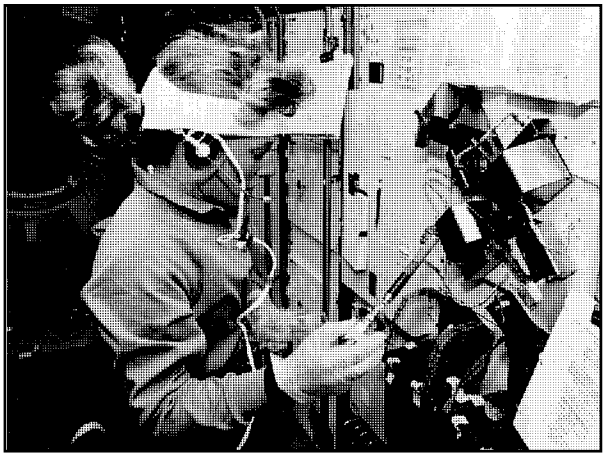
Radiation and Environmental Health
An understanding of the radiation environment in space and its effects on life forms is required for long space journeys. Fruit fly eggs or larvae were flown in incubators. When the flies hatched, they were studied for radiation induced mutations.

Secondary Payloads

STS-47 also flew the Shuttle Amateur Radio Experiment (SAREX) for the crew to communicate with schools and amateur radio operators around the world. The Israel Space Agency Investigation About Hornets (ISAIAH) examined how the oriental hornet builds its nest in microgravity. These particular hornets orientate their nests with the gravity vector here on Earth.

Educational Events

The crew also participated in several live lessons with students across the United States and in Japan. The Japanese payload specialist, Mamoru Mohri, conducted a lesson with students in Japan. Mae Jemison talked with students in Chicago, and Jan Davis talked with students in Huntsville, Alabama. The crew also videotaped several on-orbit sequences for video lessons to be produced later in both English and Japanese.



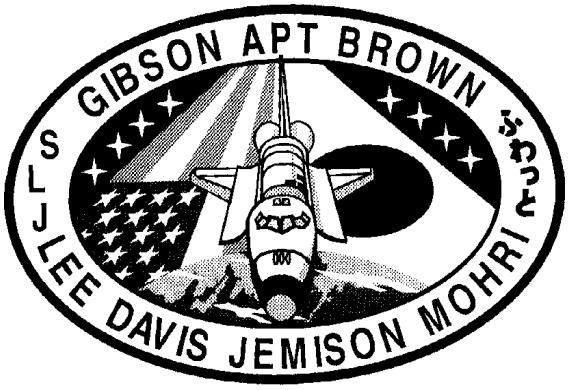
Astronaut Jan Davis works at the Continuous Heating Furnace (CHF) in the Spacelab-J. The furnace accommodated the fabrication and growth of semiconductor compounds.

Mission Facts

Orbiter: *Endeavour* (OV-105)
Mission Dates: September 12-20, 1992
Commander: Robert L. Gibson (Capt., USN)
Pilot: Curtis L. Brown (Maj., USAF)
Payload Commander: Mark C. Lee (Lt. Col., USAF)
Mission Specialist: Jerome Apt (Ph.D.)
Mission Specialist: N. Jan Davis (Ph.D.)
Mission Specialist: Mae C. Jemison (M.D.)
Payload Specialist: Mamoru Mohri (Ph.D.)
Mission Duration: 7 days, 22 hours, 31 minutes
Kilometers Traveled: 5,297,475
Orbit Inclination: 57 degrees
Orbits of Earth: 126
Orbital Altitude: 296 Km
Payload Weight Up: 11451 Kg
Orbiter Landing Weight: 99,565 Kg
Landed: KSC Shuttle Landing Facility
Runway 33

Payloads and Experiments:
Spacelab-J (SL-J)
Get-Away Special (GAS) Bridge Assembly
SAREX II - Shuttle Amateur Radio Experiment
ISAIAH - Israel Space Agency Investigation About Hornets

Educational Activities
Educational Videotapes (U.S. and Japan)
Live lesson to Japan



STS-47 Crew Patch

Crew Biographies

Commander: Robert L. Gibson (Capt., USN)
Robert Gibson was born in Cooperstown, New York, but considers Lakewood, California, to be his hometown. He earned a bachelor of science degree in aeronautical engineering from California Polytechnic State University. Following graduation, he entered active duty with the Navy. Gibson flew combat missions in Southeast Asia, serving aboard the USS Coral Sea and USS Enterprise. He later graduated from the U.S. Naval Test Pilot School at Patuxent River, Maryland, and became involved in the testing and evaluation of F-14A aircraft. He has logged more than 5,500 hours flying time and has completed over 300 carrier landings. Gibson became an astronaut in 1979. He has flown in space three times: as pilot of STS-41B and commander of the STS-61C and STS-27 flights.

Pilot: Curtis L. Brown, Jr. (Maj., USAF)
Curtis L. Brown was born in Elizabethtown, North Carolina. He received a bachelor of science degree in electrical engineering from the U.S. Air Force Academy. He flew A-10 aircraft at Myrtle Beach Air Force Base, South Carolina, before being reassigned to Davis Monthan AFB, Arizona, as an A-10 instructor pilot. While an instructor pilot, he attended the USAF Fighter Weapons School and the USAF Test Pilot School. Upon graduation from the USAF Test Pilot School, he served as a test pilot in the A-10 and F-16 aircraft at Eglin AFB, Florida. Brown has logged over 3,500 hours flight time in jets and has piloted more than 35 different aircraft. He was selected as an astronaut in 1987. His technical assignments to date include: upgrade of the Shuttle Mission Simulator; development of the Flight Data File; lead of the Astronaut Launch Support Team responsible for crew ingress and strap-in prior to launch and crew egress after landing.

Payload Commander: Mark C. Lee (Lt. Col., USAF)
Mark C. Lee was born in Viroqua, Wisconsin. He earned a bachelor of science degree in civil engineering from the U.S. Air Force Academy, and a master of science degree in mechanical engineering from the Massachusetts Institute of Technology. While assigned to Hanscom Air Force Base, Massachusetts, his responsibilities included resolving mechanical and material defects which affected the mission readiness of the Airborne Warning and Control System aircraft. Lee flew F-16s while serving as executive officer for the 388th Tactical Fighter Wing Deputy Commander for Operations, and as flight commander in the 4th Tactical Fighter Squadron at Hill Air Force Base, Utah. He has logged 2,750 hours flying time, mostly in the T-38, F-4, and F-16 aircraft. Selected as an astronaut in 1984, Lee was a mission specialist aboard STS-30.

Mission Specialist: N. Jan Davis (Ph.D.)
N. Jan Davis was born in Cocoa Beach, Florida, but considers Huntsville, Alabama, to be her hometown. She earned bachelor of science degrees in applied biology from Georgia Institute of Technology and in mechanical engineering from Auburn University, and a master of science degree and a doctorate in mechanical engineering from the University of Alabama, Huntsville. As an aerospace engineer for NASA's Marshall Space Flight Center in Huntsville, she was responsible for the structural analysis and verification of the Hubble Space Telescope and the Advanced X-ray Astrophysics Facility. She was also the lead engineer for the redesign of the Solid Rocket Booster external tank attach ring. Davis was named an astronaut in 1987.

Mission Specialist: Jerome Apt (Ph.D.)
Jerome Apt was born in Springfield, Massachusetts, but considers Pittsburgh, Pennsylvania, to be his hometown. He received a bachelor of arts degree, magna cum laude, in physics from Harvard College, and a doctorate in physics from the Massachusetts Institute of Technology. As a staff member of Harvard's Center for Earth & Planetary Physics, he supported NASA's Pioneer Venus Mission. While at NASA's Jet Propulsion Laboratory, Apt studied Venus, Mars, and the outer solar system and was Science Manager of the Table Mountain Observatory. From 1982 until his selection as an astronaut in 1985, he was a flight controller responsible for Shuttle payload operations at NASA's Johnson Space Center. He has logged over 2,500 hours flying time in some 25 different types of airplanes, sailplanes and human-powered aircraft. Apt served as a mission specialist on the STS-37 mission during which he performed two spacewalks.

Science Mission Specialist: Mae C. Jemison (M.D.)
Mae Jemison was born in Decatur, Alabama, but considers Chicago, Illinois, to be her hometown. She earned both a bachelor of science degree in chemical engineering and a bachelor of arts degree in African and Afro-American studies from Stanford University, and a doctorate degree in Medicine from Cornell University. After medical school, she did post-graduate medical training at Los Angeles County University of Southern California Medical Center. As an Area Peace Corps Medical Officer for Sierra Leone and Liberia in West Africa, she managed the health care delivery system for U.S. Peace Corps and U.S. Embassy personnel. Dr. Jemison's background includes work in the areas of nuclear magnetic resonance spectroscopy, reproductive biology, and printed wiring board materials. She also developed and participated in research projects on the Hepatitis B vaccine, schistosomaisis, and rabies. Dr. Jemison was a General Practitioner and attending graduate engineering classes in Los Angeles when named to the astronaut program in 1987. She was a co-investigator for the Bone Cell Research Experiment on this mission.

Prime Payload Specialist: Mamoru Mohri (Ph.D.)
Mamoru Mohri was born in Yoichi, Hokkaido, Japan. He earned bachelor of science and master of science degrees in chemistry from Hokkaido University, and a doctorate degree in chemistry from the Flinders University of South Australia. As a member of the faculty of Hokkaido University for ten years, he conducted research on surface physics and chemistry and on vacuum sciences. He also worked on a Japanese nuclear fusion project for eight years, and has experience working on large-scale experimental systems for plasma confinement. He was selected to participate in the first group of exchange scientists under the U.S./Japan Nuclear Fusion Collaboration Program. In 1985, Dr. Mohri was named a payload specialist by the National Space Development Agency of Japan. He has conducted microgravity experiments as an adjunct professor of the University of Alabama in Huntsville using the KC-135 aircraft and a drop tower facility at the Marshall Space Flight Center, Huntsville, Alabama.